COMPARATIVE EVALUATION OF TENSILE BOND STRENGTH, FRACTURE MODE AND MICROLEAKAGE OF FIFTH, AND SIXTH GENERATION ADHESIVE SYSTEMS IN PRIMARY DENTITION

Dissertation submitted to

THE TAMILNADU Dr.M.G.R.MEDICAL UNIVERSITY

In partial fulfillment for the Degree of

MASTER OF DENTAL SURGERY

BRANCH VIII

PEDODONTICS AND PREVENTIVE DENTISTRY

FEBRUARY 2005

CERTIFICATE

This is to certify that this dissertation titled " COMPARATIVE EVALUATION OF TENSILE BOND STRENGTH, FRACTURE MODE AND MICROLEAKAGE OF FIFTH, AND SIXTH GENERATION ADHESIVE SYSTEMS IN PRIMARY DENTITION" **is a bonafide record of work done by** Dr A. Stalin **under my guidance during his post graduate study period between 2002-2005.**

This Dissertation is submitted to THE TAMILNADU Dr. M.G.R. MEDICAL UNIVERSITY, in Partial fulfillment for the Degree of Master of Dental Surgery in Branch VIII Pedodontics and Preventive Dentistry**.**

It has not been submitted (partial or full) for the award of any other degree or diploma.

Guide:
Dr.Balagopal Varma, M.D.S
Professor and Head,
Department of Pedodontics and Preventive Denitstry,
Ragas Dental College & Hospital,
Chennai.

Dr.S.Ramachandran M.D.S
Principal,
Ragas Dental College & Hospital,
Chennai.

Acknowledgment

I would like to take this opportunity to thank my guide ***Dr. Balagopal Varma****, Professor and Head of the Department, Department of Pedodontics and Preventive Dentistry, Ragas Dental College, for his valuable guidance, support and encouragement throughout my post graduate curriculum.*

My sincere thanks to ***Dr. M. Jayanthi****, Associate Professor, Department of Pedodontics and Preventive Dentistry, Ragas Dental College, who had helped with their valuable advices and immense support where ever and whenever needed.*

I would also take this opportunity to thank my former Head of the Department, ***Dr.Thressiamma Joseph*** *for her valuable guidance and advice during my post graduation.*

My sincere thanks to ***Dr. K. P. Sanjayan****, director,* ***Gill Research Institute*** *and* ***Mr. Zakir Hussain****, PhD student,* ***Gill Research Institute****, Chennai, for providing me the necessary equipments and the help they rendered, without which this study would not have been a reality.*

I am extremely thankful to ***Dr. Mohan****, Professor, Department of Advanced studies in botany, Madras University, Chennai, for providing the opportunity to utilize their facilities in order to conduct my study.*

*I am indebted to **Er. M.Shanthi**, Professor & Head, Dept. of Physic, Annamalai University, Chidhambaram, for guiding and helping me to complete my study using Scanning Eelectron Microscope.*

*I am extremely thankful to **Er. Vasanthi,** Composite Technology Center, I.I.T, Chennai, for providing guidance to measure the tensile bond strength using Instron Universal Testing Machine.*

*I would also like to thank **Mrs.Hemalatha,** Statistician of our college, for helping me in preparing the results presented in this study.*

*I would also like to extend my thanks to **Mrs. Roopa & Ms. Vimala** for their meticulous typing and editing work and **Mr. Rajendran** who co-operated till the end in procuring the excellent photographs for this study.*

*Words cannot express how much **my parents** have done for me. Their love, understanding, support, blessings, and sacrifices motivated me to do this post graduation.*

*Last but not the least I would like to thank all my **colleagues** and my friends who have been of immense support with their encouraging words and advices, that has helped me keep myself motivated throughout.*

CONTENTS

	PAGE.NO.
INTRODUCTION	**1**
REVIEW OF LITERATURE	**4**
MATERIALS & METHODS	**25**
RESULTS	**37**
DISCUSSION	**43**
CONCLUSION	**56**
BIBLIOGRAPHY	**58**

Introduction

The foundation for modern adhesive dentistry was laid in 1955, when Buonocore reported that acids could be used to alter the surface of enamel to “render it more receptive to adhesion”. Although enamel bonding has been widely and successfully used in dentistry, the reliable dentin bonding has been possible only during the last decade.

However, bonding of resins to dentin is far more difficult and less predictable than bonding to enamel. Dentin not only has a more complex histologic structure than enamel, but also varies more with location. The composition of dentin by weight is 10% water, 25% organic matrix and 65% inorganic component, arranged in intertubular and peritubular matrices, which form the tubule walls from which pulp fluids emerge and keep dentin constantly moist. Dentinal adhesion is further complicated by the formation of the smear layer, which appears on the dentinal surface when the dentin is cut or ground.

To overcome these problems, dental adhesive systems have evolved through several “generations”, with changes in chemistries, mechanisms, number of bottles, application techniques and clinical effectiveness. The bonding mechanism to dentin was effective and predictable when the smear layer was completely dissolved, inter tubular and peritubular dentin were dissolved, collagen fibers exposed and after infiltration of

resin monomers, a hybrid layer formed. This bonding mechanism was evident from 4th to 6th generations of dentin bonding systems[12,13,16,17,21].

The total etch technique using 5th generation adhesive system proved its clinical effectiveness over 4th generation adhesive system with reduction in number of application from three to two steps. It consisted a separate etching procedure on dentinal surface before application of single bottle adhesive containing both primer and bonding agent.

A recent development involves the use of acidic or self etching adhesives which combine acid conditioning with the priming and bonding procedure known as sixth generation / self-etching adhesive system. Apart from simplification of single step application, the rationale behind this system is to superficially demineralize dentin and simultaneously penetrate it with monomers, which can be polymerized in situ. While bonding to permanent teeth has been studied extensively, few studies have addressed resin bonding to primary teeth.

Studies comparing the same adhesive systems showed results varying from no significant difference to higher or lower bond strength and sealing ability in primary dentition than in permanent dentition[13,26]. And, results of recent invitro studies have revealed the lower efficacy of self etching system than the total etching system in primary dentition[14].

Chemical, physiological and micromorphological differences such as decreased mineralization, small size and lower concentration of dentinal tubules, decreased permeability, more reactivity to acidic conditioner are thought to be responsible for lower bond strength and sealing ability in primary dentition[7,36].

The objectives of this invitro study was to comparatively evaluate the tensile bond strength, fracture mode (under SEM) and microleakage of total etching single bottle system with that of self etching adhesive system in primary dentition.

Review of Literature

The `traditional' resin-based dentin adhesives have been modified in the recent years to reduce the numerous steps in application procedure. The fifth generation dentin bonding systems can be subdivided into one-bottle adhesives and self-etching primers. One-bottle systems (total etch) combine the primer and adhesives in one solution and self-etching primer system combines the etching and priming in one step. The sixth generation system has combined the etching, priming and bonding in one step[12,13,16,17,21]. There have been various studies comparing fifth and sixth generation adhesives in terms of bond strength and microleakage.

BOND STRENGTH EVALUATION

Edward J.Swift et al[10] (1998) evaluated the shear bond strength of fifth generation total etch adhesives (One Step, Opti Bond Solo, Prime & Bond 2.1, Syntac Single Component, Single Bond, Tenure Quick with Flouride) and one conventional unfilled resin (control) in bovine incisors. In this study, the mean bond strengths ranged from 14.2 Mpa for Syntac Single Component to 27.8 Mpa for Single Bond. The mean for Syntac Single Component was significantly less than that of all other systems tested. It indicated that one-bottle (fifth generation) bonding agents; with the exception of the Syntac material provide enamel bond strength at least equal to that of a conventional unfilled resin.

Tsuneo IMAI et al[35] (1998) evaluated the effectiveness of fifth generation-total etch adhesive (Single Bond) and fifth generation-self etching primers (MB II & KB) by measuring the contraction gap width of a resin composite restored into a cylindrical dentin cavity prepared in an extracted human permanent molars and by measuring the tensile bond strength to the flat dentin surface. In addition, calcium loss during dentin conditioning was analysed using energy dispersion electron microanalyser (EDS) mounted on SEM. The mean tensile bond strength of the tested bonding system varied from 12.1 to 18.5 Mpa. The positive control group (Clearfil Photo Bond with EDTA conditioner and 35% Glycerol Mono-Methacrylate Primer) and the MB II specimen exhibited significantly higher bond strength than KB or SB. Calcium loss due to dentin conditioning was significant in the SB specimen, though decalcification from EDTA conditioning and self etching dentin priming of KB was significantly mild, over 90% of the Ca+ was residual after conditioning. With the SEM, poor margin integrity was noted in all experimental adhesive systems. Hybrid layer up to 3 mm thickness was noted only in SB and MB II groups not in KB system.

P.N.R. Pereira et al[25] (1999) evaluated the influence of intrinsic wetness on regional bond strength of fifth generation-total etch adhesive (One Step) and fourth generation-self etch adhesive (Clearfil Liner Bond

II). Human 3rd molars were divided into three groups for bonding: Group I - no pulpal pressure: Group II - Pulpal pressure of 15cm H2O. Group III - dentin dried overnight in a desiccator. Flat dentinal surfaces were used for bonding and composite resin (APX) restoration. Tensile bond strength values obtained in Group I & II of Clearfil Liner Bond II showed no significant differences. However, bond strength significantly decreased on the pulp horn region of the Group II specimens, restored with One Step. All bond strength of Group III decreased significantly and regional difference were not evident. SEM observation of fracture sites revealed the blister like structures on the pulp horn regions of specimens with One Step adhesive systems in Group II but not in Liner Bond II specimens. In conclusion, it was stated that the dentin adhesive system should be chosen according to the substrate and region to be bonded, since bond strengths vary according to the intrinsic wetness, region and the adhesive system.

Takeshi KIMOCHI et al[32] (1999) examined the adhesive properties of fifth generation-self etch system (Unifil Bond) to normal and caries infected dentin of human extracted molars using SEM and a Micro Tensile Bond Strength (MTBS) test. There was a significant difference between the MTBS to normal and caries dentin. SEM observation revealed that the typical hybrid layer was not formed on caries infected dentin and mud like structures were observed on the top of infected

dentin. These results suggested that resin infiltration into caries infected dentin was not sufficient to allow perfect sealing of the restoration.

T. Yoshikawa et al[31] (1999) evaluated the effects of dentin depth and cavity configuration on bond strength of composite resin restoration with -fifth generation total etch adhesive (One-Step (OS)), fourth generation-self etch adhesive (Clearfil Liner Bond II), and fourth generation total etch adhesive (Super Bond D liner (DL)) in human 3rd molars. In microtensile bond strength evaluation, all groups gave high bond strengths to superficial dentin, but OS & DL (total etch systems), gave significantly lower bond strength to flat deep dentin when the C factor was 1. When the C-factor was increased to 3 by the creation of a 3-dimentional-cavity preparation, the bond strengths of all materials fell (range, 21 to 35%), but the difference was significant only with DL. Under SEM, specimens with high bond strengths tended to exhibit cohesive failures with in the hybrid layer, while specimens exhibiting low bond strengths showed failures at the top of the hybrid layer. This study revealed that deep dentin reduced resin-dentin bond strength in total etch systems tested. Such adhesive systems are more susceptible to the polymerization shrinkage stress that develops in cavities with high cavity configuration factors.

M Hannig et al[23] (1999) comparatively evaluated shear bond strength of sixth generation-self etch (Etch and Prime 3.0), fifth generation-self etch (Resculin Aquaprime), fourth generation-self etch (Clearfil Liner Bond 2), and fifth generation total etch (Ecusit – Mono) systems in enamel of bovine incisors. Results obtained were 24.2 ±3.0 Mpa in Clearfil Liner Bond 2, 21.9 ± 1.4 Mpa in Etch and Prime 3.0, 34.0 ± 3.6 Mpa in Resculin Aquaprime, and 26.3 ± 1.8 Mpa in Ecusit - Mono. It reveals significant difference between the groups but there is no difference in between Clearfil Liner Bond 2 and Ecusit - Mono. In the second part of the study, extracted human molars were used for detecting marginal adaptation with these four adhesive systems. SEM observation revealed no difference in marginal adaptation between these groups. It was concluded that self-etching primers might be an alternative to conventional phosphoric acid pre-treatment in composite-to-enamel bonding restorative techniques.

Some studies have addressed the ultrastructural variations in primary dentin than that of permanent dentin. David A Sumikawa et al[7] (1999) showed substantial differences in the microstructure of primary dentin as compared to permanent dentin, substantial differences with location and the relatively common occurrence of microcanals (5 to 10mm in size) in primary teeth. Therefore, the area of solid dentin that is available for dentin bonding is significantly reduced, accounting for

reported differences in bond strength. Such differences may be important factors in tooth sensitivity, susceptibility to trauma, and caries progression. V.Koutsi et al[36] (1994) also reported the similar ultra structural variations in primary dentin.

J Perdigao et al[19] (2000) evaluated the effect of different phosphoric acid-based conditioners on dentin shear bond strengths of fifth generation total etch bonding systems (OptiBond Solo, Permaquick PQ1, and Single Bond) and the corresponding interfacial ultra morphology using TEM. Silica-thickened etching gels, 37.5% phosphoric acid gel (Ultraetch), and 35% phosphoric acid gel (Scotchbond Etching Gel) were used as conditioners. The mean shear bond strengths were not statistically different for dentin adhesives and for etching gels, the number of cohesive failures was greater for Permaquick PQ1 and for Ultraetch, respectively. The ultramorphological observation showed that all materials penetrated the dentin and formed a hybrid layer, regardless of the etching gel used. And no correlation between hybrid layer thickness and bond strengths was found.

M Yoshiyama et al[24] (2000) evaluated the interfacial morphology of fifth generation total etch and self-etch adhesive systems (Single Bond (SB) and FluoroBond (FB)) to caries-affected dentin, coupled with the measurement of microtensile bond strengths (MTBS). Resin -dentin

interfaces were observed with SEM before or after acid challenge. Bonding to normal dentin with the two bonding systems (SB and FB) showed tensile bond strengths significantly higher than those to caries-affected dentin. The moist bonding technique significantly increased bond strength of SB to normal and caries-affected dentin. SEM examination revealed that typical hybrid layer and resin tags could not be formed to caries-affected dentin. The results suggested that resin penetration might be prevented by occlusion of dentinal tubules by mineral deposits that may also impart acid-resistance to the intertubular matrix of caries-affected dentin.

While most of the studies evaluated the bond strength in permanent teeth, there have been few studies, which evaluated bond strengths in primary dentin. Yumiko Hosoya et al[40] (2000) evaluated the shear bond strength of fifth generation-self etch adhesive (Imperva fluorobond) and obtained a similar shear bond strength value in primary enamel and dentin and permanent enamel and dentin. The values ranged from 14.39 to 16.34 without any statistically significant difference. SEM study revealed high percentage of mixed fracture in primary enamel, primary dentin and permanent dentin but permanent enamel showed more percentage of adhesive fracture.

The first description of sixth generation adhesive system in clinical situations was given by Theodore P. Croll[34] (2000). He reported the effective bonding of compomer to tooth structure using the sixth generation self-etching adhesive system (Promt L-Pop). He has described the procedure of bonding with Promt L-Pop in two clinical situations: (1) compomer restoration in class V cavities in right primary central and lateral incisors of a three year old girl and (2) developing a compomer slope on the right central incisor to correct the single tooth cross bite position in a seven year old boy. It was concluded that if in vivo studies and practical experience confirm that such bonds are durable and will reliably hold up for the long term, the self etching system will be known as a major advancement in simplifying and enhancing procedures in clinical adhesive dentistry.

Edward J. Swift et al[11] (2001) evaluated the 36-month clinical performance of filled and unfilled - fifth generation total etch adhesives (OptiBond Solo and Prime & Bond 2.1) on Class V restorations placed without retentive grooves or enamel bevels. The result showed that the retention rates were 93.3 percent for the ethanol-based adhesive and 89.4 percent for the acetone-based adhesive. The difference in retention rates was not statistically significant. In both groups, 12 percent of the retained restorations had marginal staining, but no recurrent caries was detected around any restoration. Other restoration characteristics such

as marginal adaptation and color match remained excellent three years after placement.

JR Gallo et al[20] (2001) compared the shear bond strength of fifth generation total etch adhesives (One Coat, Bisco One Step, Prime & Bond 2.1 and Single Bond) when applied on the dentin surface immediately after dispensing and 10 minutes after dispensing. The statistical analysis showed that there was no significant difference between both the groups, although the dentin bonding agents containing acetone showed a trend towards lower bond strengths when not used immediately after dispensing.

L Zheng et al[22] (2001) evaluated the effect of the thickness of the adhesive resin layer of fifth generation total etch and self-etch adhesive systems (Single Bond and Liner Bond 2V) on bond strengths. The thickness of the Clearfil Liner Bond 2V adhesive layer ranged from 5 mm - 1500 mm, and for Single Bond, it varied from 7.5 mm - 430 mm. For Clearfil Liner Bond 2V, bond strengths increased significantly as the thickness of bonding layer increased ($p<0.05$). However, the bond strengths of the Single Bond decreased significantly with increased thickness of the bonding layer ($p<0.05$).

A few studies have addressed the etching pattern of self etching adhesive systems in dentin. Franklin R.Tay et al[15] (2001) examined, with the use of transmission electron microscopy (TEM), the aggressiveness of three self-etching systems in penetrating dentin smear layers of different thickness. It was concluded that the contemporary self etching systems may be classified as mild (Clearfil Mega Bond), moderate (Prime &Bond NT with Non-Rinse Conditioner) and aggressive (Prompt L-Pop) based on their ability to penetrate dentin smear layers and their depth of demineralization into the subsurface of dentin. The more aggressive (Prompt L-Pop) system completely solubilized the smear layer and smear plugs and formed hybrid layers with a thickness approaching those of phosphoric acid conditioned dentin.

Francesca G. Agostini et al[14] (2001) evaluated the tensile bond strength of sixth generation-self etching adhesive systems (Prompt L-Pop, Etch and Prime 3-0), fifth generation-self etching primer system (Clearfil SE Bond) and fifth generation-total etch adhesive system (Prime and Bond NT) to primary enamel and dentin. Results showed that Prime and Bond NT had significantly higher bond strength (25.9Mpa) than bonding with the three acidic primers- Prompt L-Pop (18.5Mpa), Clearfil SE Bond (18.7 Mpa), Etch and Prime 3-0 (19.3 Mpa) in primary enamel. Complete bond failures occurred with Prompt L-Pop and Etch and Prime 3-0 to primary dentin. With a mean of 39 Mpa, the bond strength to primary

dentin with Clearfil SE Bond was significantly higher than with Prime and Bond NT (12.5 Mpa). The majority of specimens had adhesive and mixed fractures. It was concluded that all the four adhesive systems tested bonded effectively to primary enamel, but only CSE achieved adequate bond strength to primary dentin.

Y. Nakaoki et al[37] (2002) investigated the effect of residual water on dentin bond strengths and hybrid layer formations of fifth generation-total etch adhesive system (Single Bond). The blot dry and one-second dry group showed higher bond strengths than the over wet and desiccated groups. Hybrid layer formation up to 5 mm thickness was noted in over wet and blot dry groups. In the one-second dry group, hybrid layer formation was not as good even though the bond strength was high. He concluded that from the clinical standpoint, wet bonding is believed to be a very technique sensitive method. This has also been analysed previously by Thomas Jacobson and Karl-Johan Soderholm[33] (1995).

Y Shimada et al[38] (2002) compared the shear bond strength of fifth generation total etch and self etch adhesive systems (Single Bond and Clearfil SE bond) to primary and permanent teeth enamel. In addition, etched enamel surfaces and etched-bonded enamel interfaces were examined using SEM. No statistically significant differences of shear

bond strength values were found between the primary and permanent enamel for both the adhesive systems used. The SEM observation showed that both adhesive systems etched the primary enamel deeper than the permanent enamel, suggesting that the action of acid etch seemed to be more intense on primary enamel than on permanent enamel. Bonding of the adhesive systems to primary enamel was almost identical to permanent enamel.

ED Bonilla et al[9] (2003) evaluated the interaction of five clinical application techniques and the shear bond strength of fifth generation total-etch adhesives (OptiBond FL, Clearfil SE Bond, PQ1 and Prime & Bond NT). Group A-adhesive spread with a 3M brush for 30 seconds, followed by compressed air 0.5 cm from the surface for one second to remove the excess adhesive. Group B-adhesive spread with a 3M brush for 30 seconds, followed by compressed air 0.5 cm from the surface for three seconds to remove the excess adhesive. Group C-adhesive spread with 3M brush for 30 seconds, excess adhesive removed with a clean brush, two strokes side by side, no compressed air. Group D-adhesive spread with a Micro-applicator brush for 30 seconds followed by compressed air 0.5 cm from the surface for one second to remove the excess adhesive. Group E-adhesive spread with a Micro-applicator brush for 30 seconds, the excess adhesive removed with a clean brush, two strokes side by side and no compressed air. This in vitro study concluded

that there was an interaction between the application technique and bonding agent tested. All adhesives utilized the one-second compressed air technique, which yielded the highest bond strengths.

S Guzman-Armstrong et al[29] (2003) evaluated the correlation between microtensile dentin bond strength and silver ion penetration using fifth generation self-etch primer system (Clearfil SE Bond) and fourth generation total-etch systems (Optibond FL and Scotch Bond Multi- Purpose). No significant correlation between microtensile bond strength and nanoleakage was found for all systems. A weak-to-moderate negative relationship was found between MTBS and nanoleakage for OptiBond FL. No correlation was found for the remaining adhesive systems. The correlation between these two common laboratory measurements appears to be adhesive-system dependent.

Y Shimada et al[39] (2003) investigated the bonding of fifth generation self-etch primer system (Clearfil SE Bond) and fifth generation total-etch wet bonding systems (Single Bond and One-Step) to the region approximating the dentin-enamel junction (DEJ), where the etch pattern to enamel or dentin may be different. In addition, morphological observations were performed on debonded specimens and etched surfaces using confocal laser scanning microscopy (CLSM). CLSM observations showed that the DEJ region was etched more deeply by

phosphoric acid gel than the enamel or dentin, suggesting that the action of acid etch seemed to be more intense on the DEJ. However, no statistically significant differences of shear bond strength values were observed between the DEJ region and enamel or dentin, or the adhesive systems used ($p>0.05$). Bonding to the DEJ is potentially as good as that to enamel or dentin.

Zafer C. Cehreli et al[41] (2003) evaluated the effect of dentinal tubule orientation on the micro tensile bond strength of fifth generation total etch adhesive (Prime &Bond NT) in compomer restoration to primary dentin. Through this study, the following conclusions were drawn; 1) Dentin tubule orientation may affect the micro tensile bond strength of the compomer material to primary dentin. 2) The oblique and parallel direction of dentinal tubules in a proximal primary tooth cavity may favor the quantity of the bond, when a total etch techniques is performed. 3) Independent of the tubule direction, the bond strength to primary dentin is very low. This would further necessitate macro retentive preparation techniques for proximal restorations in primary teeth that need to endure.

Ziad D. Baghdadi et al[42] (2003) evaluated the effect of Phosphoric Acid etching and Non-Rinse Conditioner combined with a fifth generation total etch adhesive (Prime & Bond NT) on shear bond strength of

compomer material to dentin of permanent and primary molars. Through this study, the following conclusions were drawn; 1) for both permanent and primary dentin, mean shear strength of bonded Dyract AP cylinders after conditioning with NRC were remarkably lower than those obtained after acid etching with Phosphoric Acid. 2) The type of dentin tissue didn't influence bond strengths. 3) Bond failure after conditioning with NRC was solely due to adhesive fracture for both primary and permanent dentin. Bond failure after acid etching was mostly due to mixed fracture in the permanent dentin and due to dentin, adhesive and cohesive fracture in the primary dentin.

MICROLEAKAGE EVALUATION

C.Lucena Martin et al[4] (2001) evaluated the microleakage of six-fifth generation-total etch adhesive systems (One Step, Prime & Bond 2.0, Syntac Single, Single Bond, Optibond Solo, and Syntac Sprint) in class V composite restoration in permanent anteriors. All the groups showed minimal leakage at the enamel (coronal) margins with increased leakage at the gingival margins. Optibond Solo showed the best outcomes among the dentin adhesives tested. Additionally they found no effect of different duration of the dye immersion and thermocycling on marginal leakage of these systems.

Paloma Dias da Silva Telles et al[26] (2001) revealed that the quantity of the interfacial seal was similar in primary and permanent teeth when a sixth generation self-etching adhesive system was used for dentin bonding. Through a SEM study, they found that all the teeth restored with composite resin had a visible hybrid layer in the area bonded with a fifth generation-total etching adhesive system (Single Bond) and no hybrid layer in the area bonded with sixth generation-self etching adhesive system (Prompt L-Pop). They speculated that the low pH of Prompt L-Pop, which is required for the etching of tooth structure, may have impaired the polymerization of the resin monomers and therefore not allowed for the development of a strong and stable hybrid layer to prevent the opening of interfacial gaps.

R. Sakoolnamarka et al[27] (2002) compared the thickness of formed hybrid layer in normal dentin and noncarious cervical lesion by using fifth generation-total etch adhesive system (One Coat Bond) and self-etch adhesive system (Clearfil SE Bond) and a RMGIC (Fuji II LC) in human premolars. They found decreased thickness of hybrid layer in self-etch system than the total etching system and decreased thickness of hybrid layer in dentin of non-carious cervical lesion by using both type of bonding systems.

A El.Housseiny et al[3] (2002) compared the ability of fifth generation-total etch adhesive system (Single Bond) with fourth generation total etch adhesive system (Scotch Bond Multi Purpose plus) in reducing microleakage around class V composite restoration in primary teeth. In this in vivo study, class V cavities were prepared on facial surfaces of upper / lower canine. One canine was randomly selected for restoration using the Scotch Bond Multi Purpose plus and its antimere for the Single Bond adhesive. Then cavities were restored with composite resin (Z-100) and teeth were extracted 1 month later, immersed in 2% basic fuchsin, and then sectioned to evaluate dye penetration. Neither of the two adhesive systems was able to completely prevent leakage of class V restorations. It was concluded that one bottle adhesive performed equally well in terms of microleakage compared with multiple step adhesive.

Donald C. Schmitt and Jacob Lee[8] (2002) compared the in vitro microleakage of fifth generation total etch filled and unfilled adhesive systems (Single Bond, and Opti Bond Solo) with fourth generation total etch filled & unfilled adhesive resin systems (Optibond FL and Scotch Bond Multipurpose) in primary and permanent teeth. They found no significant difference in microleakage of both systems. So they concluded that one bottle, fifth generation total etch adhesive systems

permitted easier application with the same effectiveness as the two bottle, fourth generation total etch systems.

Danielson Guedes Pontes et al[6] (2002) compared the microleakage of sixth generation self etch adhesive systems (Etch & Prime 3.0, Prompt-L-Pop) and fifth generation total etch adhesive system (Prime & Bond 2.1) on enamel and dentin margins of class V cavities prepared in bovine teeth. The teeth were immersed in a 50% silver nitrate solution for 24 hrs and then put in a developing solution for 15 minutes. The specimens were sectioned vertically and buccolingually, then microleakage was evaluated. Among the adhesive systems used in this study, Prompt-L-Pop provided the least microleakage in enamel; however there were no statistically significant differences among the groups in dentin margins.

RM Gagliardi et al[28] (2002) evaluated the microleakage of sixth generation self etch adhesive systems (Etch and Prime 3.0, Prompt-L-Pop), fifth generation total etch adhesive systems (Single Bond, Prime and Bond NT, Excite, Durafill Bond), and Vitremer (control group) in Class V cavities of human permanent teeth. Specimens were thermocycled for 200 cycles, and stained in 50% AgNO3 solution for 12 hrs. Then teeth were longitudinally sectioned and microleakage was scored under stereomicroscope. This study revealed significant leakage at dentin margins for all adhesive systems, when compared to the control. Except for Durafill Bond, no significant difference was found between

sixth generation self etch adhesives and fifth generation total etch adhesive systems.

D. Gillet et al[5] (2002) evaluated the microleakage and the penetration depth of three pit and fissure sealants (Helioseal F, Tetric, Tetric Flow) and the effect of sixth generation self-etch adhesive (Prompt L Pop) and fifth generation total etch adhesive (Scotch-bond 1) in Tetric Flow group. There was no significant difference ($p > 0.03$) between adhesive systems in obturating the fissures of noncarious bicuspids with Tetric Flow. It is concluded that for prevention by sealing using a flowable ceromer (Tetric Flow) with the self-etching adhesive (Prompt L-Pop), is a really good technique.

Heping Li et al[18] (2002) evaluated the effects of load cycling on nanoleakage of occlusal flat surface or cervical restorations bonded with sixth generation self-etch system (Prompt L-Pop), fifth generation self-etch systems (Clearfil SE Bond and Unifil Bond), and fifth generation total etch adhesive system (Single Bond). Field Emission-SEM images showed that samples subjected to load cycling had leakage patterns similar to non-load-cycled samples for all dentin bonding systems. Load cycling did not affect leakage lengths in any system. Prompt L-Pop had greater silver deposition and leakage than the other systems.

A. Ruya Yazici et al[2] (2002) compared the microleakage of composite restorations by using sixth generation-self etch adhesive system (Prompt L pop), fifth generation-self etch adhesive system (Clearfil SE bond, and acid etching plus Clearfil SE bond) and, fifth generation total etch bonding systems (Gluma One Bond), fourth generation self etch bonding system (Optibond FL) in class II cavity prepared in premolars. In this study, all the tested systems were able to eliminate microleakage completely in the occlusal walls, but some systems (Prompt L Pop & Clearfil SE bond) exhibited statistically significant differences in leakage in the gingival walls. The greatest microleakage was observed in Prompt-L-Pop specimens.

Susanne Szep et al[30] (2003) examined the etching effects of phosphoric acid versus a combination of phosphoric and hydrofluoric acid by evaluation of microleakage in composite restorations bonded with sixth generation self etch adhesive (Etch and Prime3.0) and fifth generation total etch adhesives (Optibond Solo, Prime & Bond NT, Scotchbond 1, and Syntac Single Component, Syntac Sprint).Difference in dye penetration were significant, both as a function of the dentin adhesive and the conditioning mode applied. In the specimen groups conditioned with phosphoric acid, Optibond Solo and Syntac Sprint demonstrated the lowest dye penetration values. Prime & Bond NT, Scotchbond 1, Etch & Prime 3.0, and Syntac Single Component showed

higher dye penetration values. Total-etching water-based Syntac Single component and Syntac Sprint exhibited significantly better results when conditioned with a combination of phosphoric acid and hydrofluoric acid than with phosphoric acid only. Ethanol-based dentin bonding agents (Etch & Prime 3.0 Optibond Solo, and Scotchbond 1) were not significantly influenced by the type of conditioner used.

Materials and Methods

This study was done in Department of Pedodontics, Ragas Dental College, Chennai. The tensile bond strength was tested at IIT, Chennai and microleakage was tested at GIL Research Institute, Chennai. SEM study to know the fracture mode was done at Annamalai University, Chidambaram.

Materials used for this study were:

1. 40 freshly extracted human primary molars (fig.1)
2. Distilled water
3. Airmotor handpiece with diamond disc
4. Airotor hand piece with No.330 bur
5. Silicon carbide sand paper 600 grit with mandrill
6. Self cure acrylic resin
7. 26 gauge ligature wire
8. Artery forceps
9. Cutter
10. Tweezer
11. Condenser
12. Dental wax
13. Spectrum 800 light curing unit (Vivadent) (fig.5)
14. Basic fuchsin dye –2% (fig.12)

15. Nail polish
16. Acid etchant
17. Single Bond Adhesive (3 M- ESPE]
18. Adper Prompt Adhesive (3M- ESPE)
19. Z-100 composite resin (3M)
20. Metal mould (splitting type with an inverted cone shaped hollow)
21. PCR thermocycling unit
22. Stereomicroscope
23. Instron Universal Testing Machine (Model no.4301)
24. Auto Fine Coater (JOEL – JFC – 1600)
25. SEM (JOEL – JSM – 5610LV)

Composition of Adhesive material

Single Bond (3M-ESPE):

BIS-GMA, HEMA, Dimethacrylates, Polyalkenoic Acid Copolymer, Ethanol, Initiator and Water.

Adper Prompt (3M-ESPE):

Bottle 1 – Methacrylated Phosphoric Ester, Glycidyl Methacrylate, Camphoroquinone and Fluoride.

Bottle 2 – Hydorxyethyl Methacrylate, Vitrebond Copolymer, Stabilizer and Water

Tensile Bond Strength Evaluation

A total of 20 freshly extracted carries free, unrestored human primary molars were selected and stored in distilled water. The buccal / lingual surfaces were ground using a water-cooled diamond disc mounted on an air-motor handpiece (fig.3) until enamel was removed. Then 600 grit – Sic paper was used with mandrill (fig.3) to create a flat dentinal surface with enamel at periphery.

Then two examiners crosschecked the specimens to confirm whether the preparation was on superficial layer of dentin.

The opposite side of prepared teeth were embedded into the self - cure acrylic resin blocks during setting in an alginate mould. After setting, the resin blocks were removed from the mould and randomly divided into 2 groups of 10 specimens each.

In group –I (Fifth Generation Group), the buccal / lingual surfaces of specimens were treated with 35% phosphoric acid for 15 seconds and rinsed with water for 10 seconds. Then excess water was dried with oil free compressed air for 5 seconds.

Single Bond adhesive (fig.2) was applied on the etched dentinal surface using a fully saturated brush tip of adhesive for each coat and two consecutive coats were applied and thinned with a gentle stream of air for 2 to 5 seconds and light cured for 10 seconds.

In group- II (Sixth Generation Group), solutions from 2 bottles of Adper Prompt (fig.2) were mixed, applied over buccal / lingual surfaces of the specimens and massaged for 15 seconds according to manufacturer's instruction. A second coating was applied and thinned with a gentle air stream and light cured for 10 seconds.

Specimens of each group were kept separately and the following procedures were done similarly.

A hollow metal split dye/mould (fig.4) was used to develop an inverted composite resin cone on adhesive treated surface of specimens. The diameter of the inverted cone shaped hollow was 2 mm at the lower end (near to the tooth surface) 4 mm at the upper end and 5mm in height.

Mould was held on the dentinal surface, then composite resin of thickness 2mm was placed inside the mould and condensed. A 26 gauge ligature wire was twisted at one end and a loop was formed at the other

end (fig.4). Twisted end was placed inside the 2mm of composite resin, held straightly and light cured for 40 seconds.

Another 2mm thickness of composite resin was placed over the first increment and light cured for 40 seconds. Another 1mm thickness of composite resin was placed over the second increment and cured for 40 seconds.

Following complete curing, the metal mould was split and removed leaving the 5mm thickness of resin cone with twisted wire bonded to 2mm surface area of dentin (fig.6). The metal mould was reused for other specimens in the same way. A few specimens that showed a spontaneous bond failure during removal of the mould were discarded and not included in the study.

All the specimens were immersed in water for 24 hours. Then, tensile bond strength was measured using an Instron Universal Testing Machine (fig.7).

The resin block was clamped to the stable lower jaw of the Instron machine and the wire loop on to the upper jaw (fig.7). A cross head speed of 0.5 mm /minute was selected and tensile load was applied on the

specimen until the composite inverted cone was dislodged from the surface of tooth.

The breaking load values for each specimen were recorded through a computer connected to Instron machine. The values obtained were in 'Kg' and bond strength was calculated using the formula mentioned below, and expressed in 'Mpa'.

$$\text{Bond strength (in Mpa)} = \frac{\text{Breaking load}}{\text{Surface area in mm}^2}$$

Surface area = πr^2 (r = radius of bonded material)

Means and standard deviation were calculated. The tensile bond strength data were analysed by Levene's test for equality variance and ' t' test for equation of means.

SEM EVALUATION OF FRACTURE MODE

After testing the tensile bond strength, specimens were selected from each group, using systematic random sampling method that is every third specimens (3, 6 & 9) from each group of 10 specimens. It might represent the majority of fracture mode of each group.

The tooth part of each specimens were wet ground by a metal disc in an airmotor handpiece to get a 5mm^2 tooth specimen without any disturbance to the de-bonded surface.

The wire elements were cut from the de-bonded resin cones without any disturbance to the de-bonded surface. Then, a total of 6 pair of tooth and resin specimens were kept separately in six polythene packets with their respective group name and number.

After dehydration of tooth and resin specimens in a hot air oven, they were mounted in a sputter coater (auto fine coater) and platinum coating was given on de-bonded surfaces under a small electric field at vacuum.

Then specimens (fig.8) were transferred to SEM (fig.9) and examined at 50x magnification. Fracture mode was designed according to the following criteria:

- If the resin part was noted on tooth specimen, the fracture mode was -resin cohesive
- If the adhesive layer was noted on both the specimens, the fracture mode was- adhesive

Fig. 1. Primary molars in water

Fig. 2. Materials

Fig. 3.Armamentarium

Fig. 4.Armamentarium

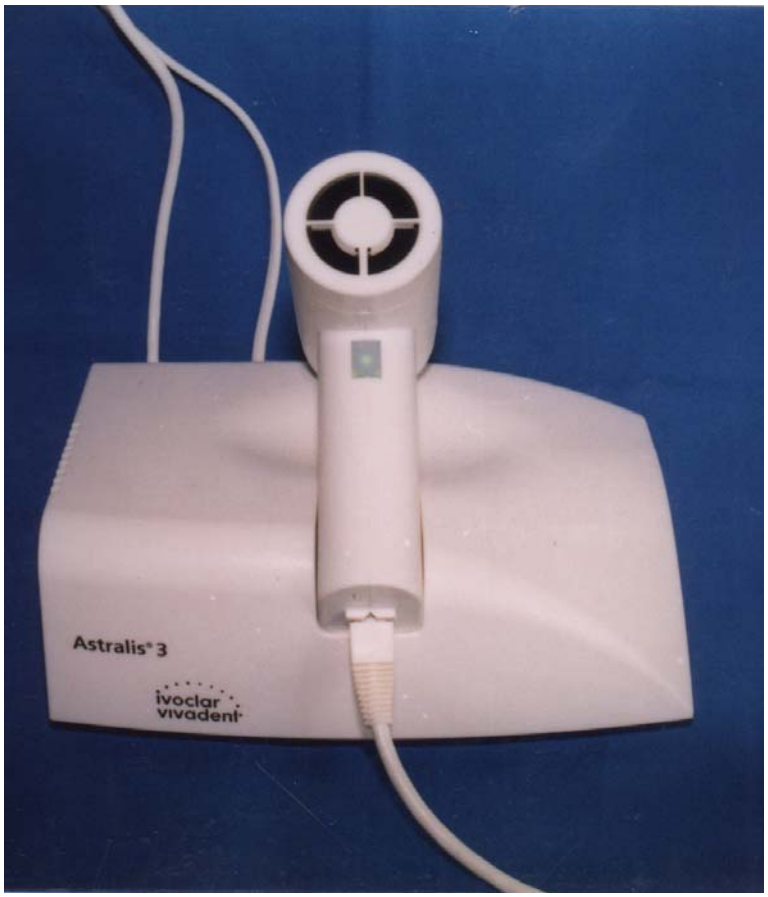


Fig. 5. Light cure unit

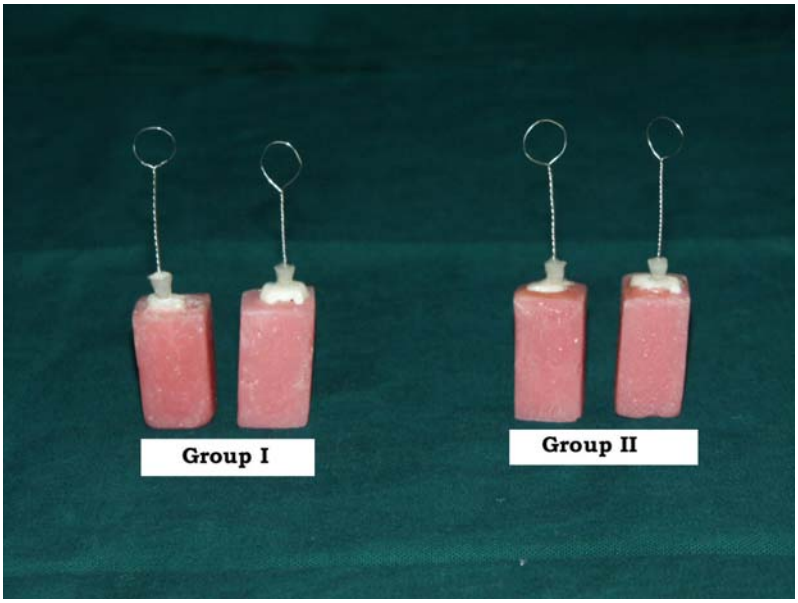


Fig. 6. Specimens for tensile bond strength evaluation

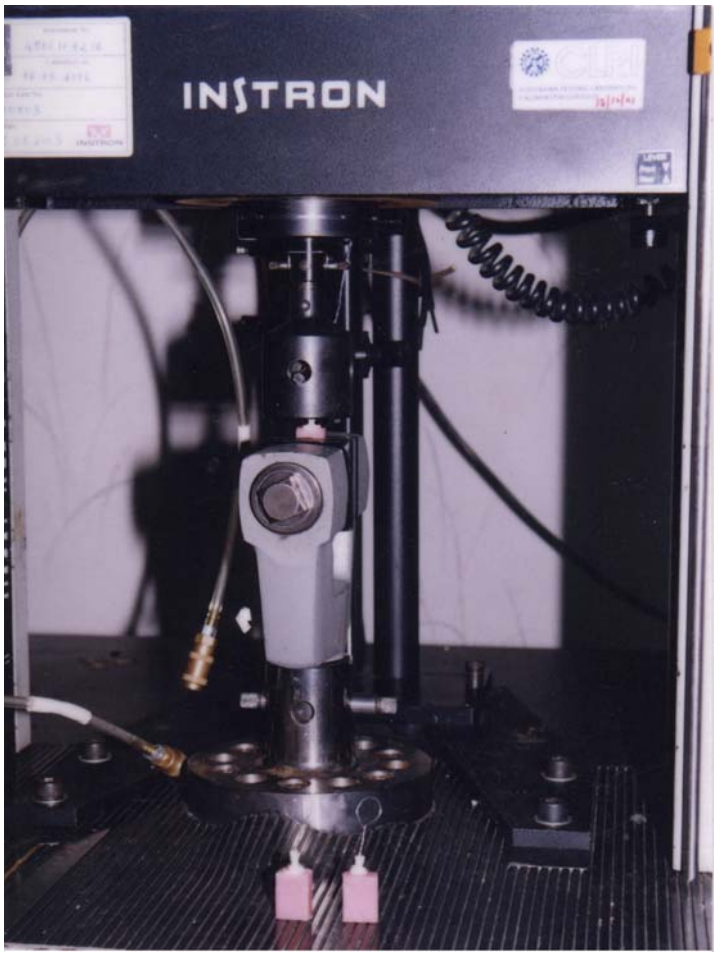


Fig.7. Instron Machine with specimens

Fig. 8. Specimens for fracture mode evaluation

Fig. 9.Scanning Electron Microscope

- If the dentinal part was noted on resin specimen, the fracture mode was- dentin cohesive
- If the resin/adhesive parts were noted on tooth specimen, the fracture mode was -mixed.

The fracture modes were not analyzed statistically to correlate with tensile bond strength.

MICROLEAKAGE EVALUATION

A total of 20 freshly extracted- caries free, unrestored human primary molars were selected and stored in distilled water.

One class V cavity preparation in enamel with rounded outlines- 3 mm width, 2 mm height and 2 mm depth was prepared in buccal/lingual surface of all teeth (fig.10) with a No.330 bur in airotor hand piece (fig.3).

Two examiners crosschecked all the specimens to confirm that the above-mentioned measurements of class V cavity preparation were adhered to. Then the specimens were randomly divided into 2 groups of 10 teeth each.

In Group I (Fifth Generation Group), the cavity walls were treated with 35% phosphoric acid for 15 seconds, rinsed with water for 10 seconds, and dried with a gentle air stream for 5 seconds.

Single Bond adhesive was applied to the etched walls using a fully saturated brush tip of adhesive for each coat, two consecutive coats were applied and thinned with a gentle air stream and light cured for 10 seconds.

In Group- II (Sixth Generation Group), solution from 2 bottles of Adper Prompt were mixed, applied over the walls of the cavity and massaged for 15 seconds according to the manufacturer's instructions. A second coating was applied and thinned with a gentle air stream and light cured for 10 seconds.

Specimens of each group were kept separately and the following procedures were done similarly.

All the cavities were filled (fig.11) with composite resin (Z-100), condensed and light cured for 40 seconds. Then immersed in water for 24 hours.

Teeth were thermocycled in PCR chamber at 5 to 55^0 C for 200 cycles with a dwell time of 30 seconds and a temperature changing time of 3 minutes in between each cycle. After thermocycling the apices of all teeth were sealed with dental wax to prevent apical leakage during the dye immersion.

Two coatings of nail varnish were done within 1mm of margins of all restorations. The specimens were then immersed in 2 % aqueous solution of basic fuchsin dye (fig.13) for 24 hours at room temperature.

After removal from the dye, the teeth were washed, dried and sectioned labiolingually (fig.14) through the middle of the restoration using a diamond disc in an airmotor handpiece.

Each section was examined using a stereomicroscope at 40x magnification to assess dye penetration at the margins of the restoration (fig.15).

The degree of micro leakage was evaluated and scored as follows:

Score 0: No dye penetration

Score 1: Dye penetration along occlusal / or gingival wall up to less than 1/3 length of the wall

Score 2: Dye penetration along occlusal and / or gingival wall up to 2/3 but not less than 1/3 length of the wall.

Score 3: Dye penetration along occlusal and / or gingival wall for whole length and along the axial wall.

The maximum score of micro leakage was measured in any half of the specimens.

Scores of micro leakage in two groups were cross-tabulated and analysed by chi-square test.

Fig. 10. Class V cavities

Fig. 11. Restored teeth with DBAs and composite

Fig. 12 Materials for microleakage study

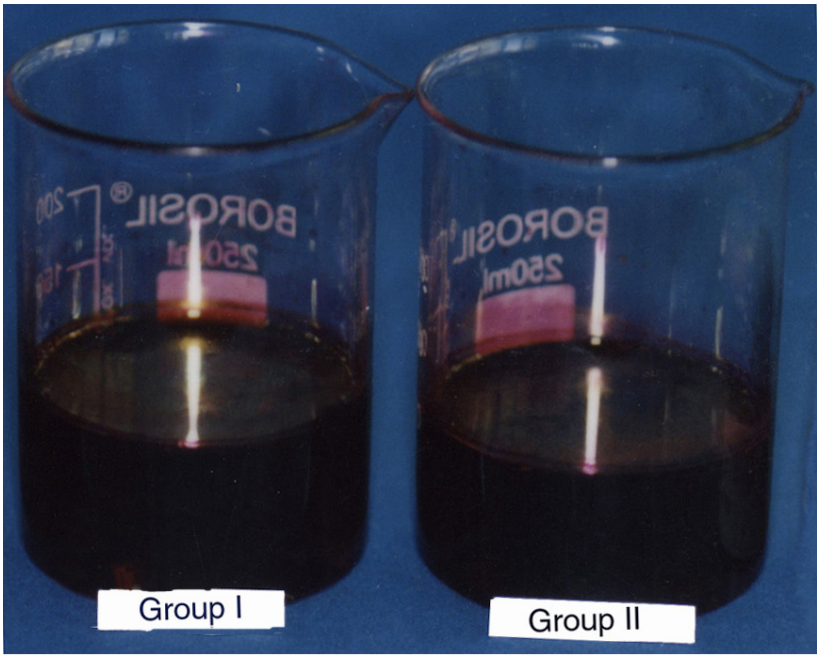


Fig. 13. Specimens in dye solutions

Fig. 14 Cross section of teeth

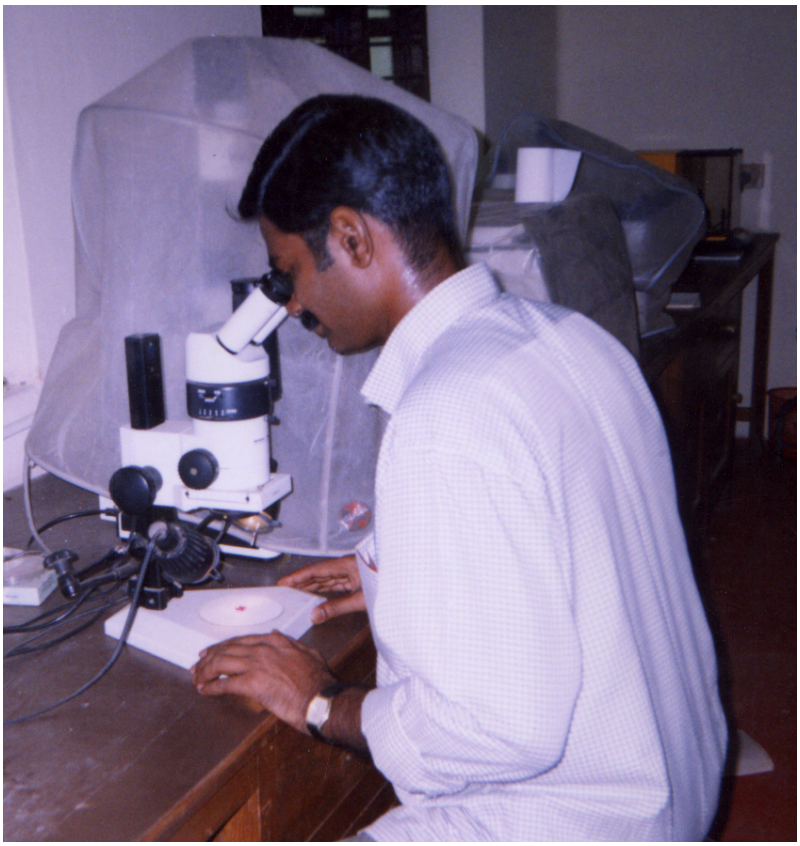
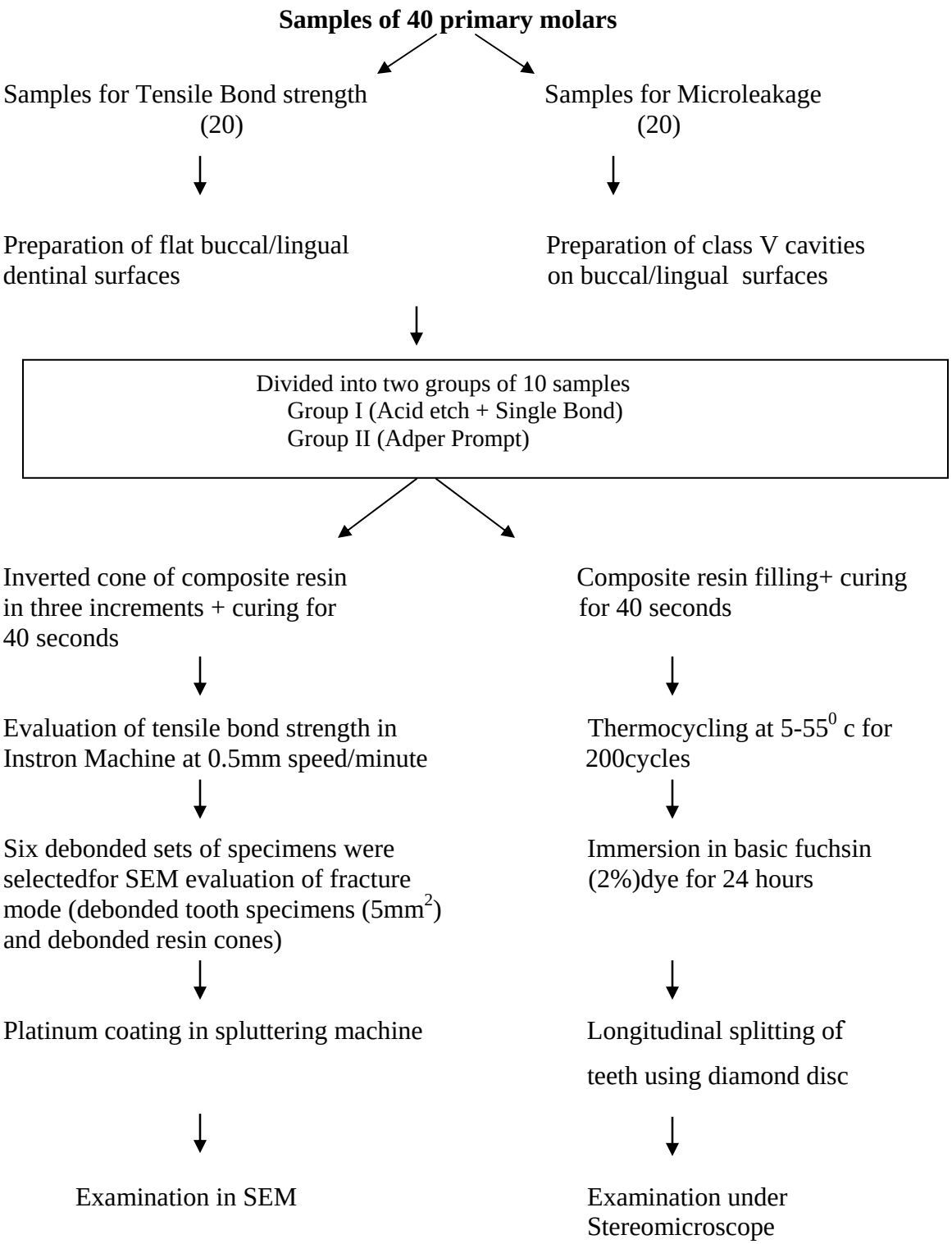


Fig. 15 Stereomicroscope

Methodology



Results

Tensile Bond Strength:

Specimens of two groups (Single Bond and Adper Prompt) were tested for tensile bond strength in the Instron Universal Testing Machine. The values obtained were in “kg” and then converted into Mpa.

The tensile bond strength values for ten specimens from each group are presented in table 1 and in figure 16. The values vary from 9.70 to 16.03 for Single Bond group and 7.58 to 16.32 for Adper Prompt group.

The mean value for tensile bond strength, standard deviation and standard error for mean values are presented in table 2.

The levene’s test for equality variances, T test for equality of means and 95% confidence interval of the differences are presented in table 3.

The obtained P value was above 0.05. So there is no statistically significant difference in tensile bond strength values between these two groups.

Table-1

Tensile Bond Strength (in Mpa)

Single Bond	Adper Prompt
11.53	10.34
12.96	14.55
14.75	14.40
13.61	12.42
12.67	15.44
16.03	13.36
13.86	11.28
11.73	9.20
9.70	7.58
12.30	16.32

Table 2

Group Statistics for Tensile Bond Strength

Group	N	Mean	Std.Deviation	Std.Error Mean
Single bond	10	12.9170	1.7798	.5628
Adper prompt	10	12.4630	2.8306	.8951

Table 3

Independent Samples Test

	Levene's Test for Equality of variances		t-test for Equality of Means						
	F	Sig.	T	Df	Sig (2-tailed)	Mean Diff	SD. Err Diff	95% confidence interval of the Difference	
								Lower	Upper
Equal variances assumed	2.826	.110	.429	18	.673	.4540	1.0574	-1.767	2.6754
Equal variances not assumed			.429	15.154	.674	.4540	1.0574	-1.797	2.7057

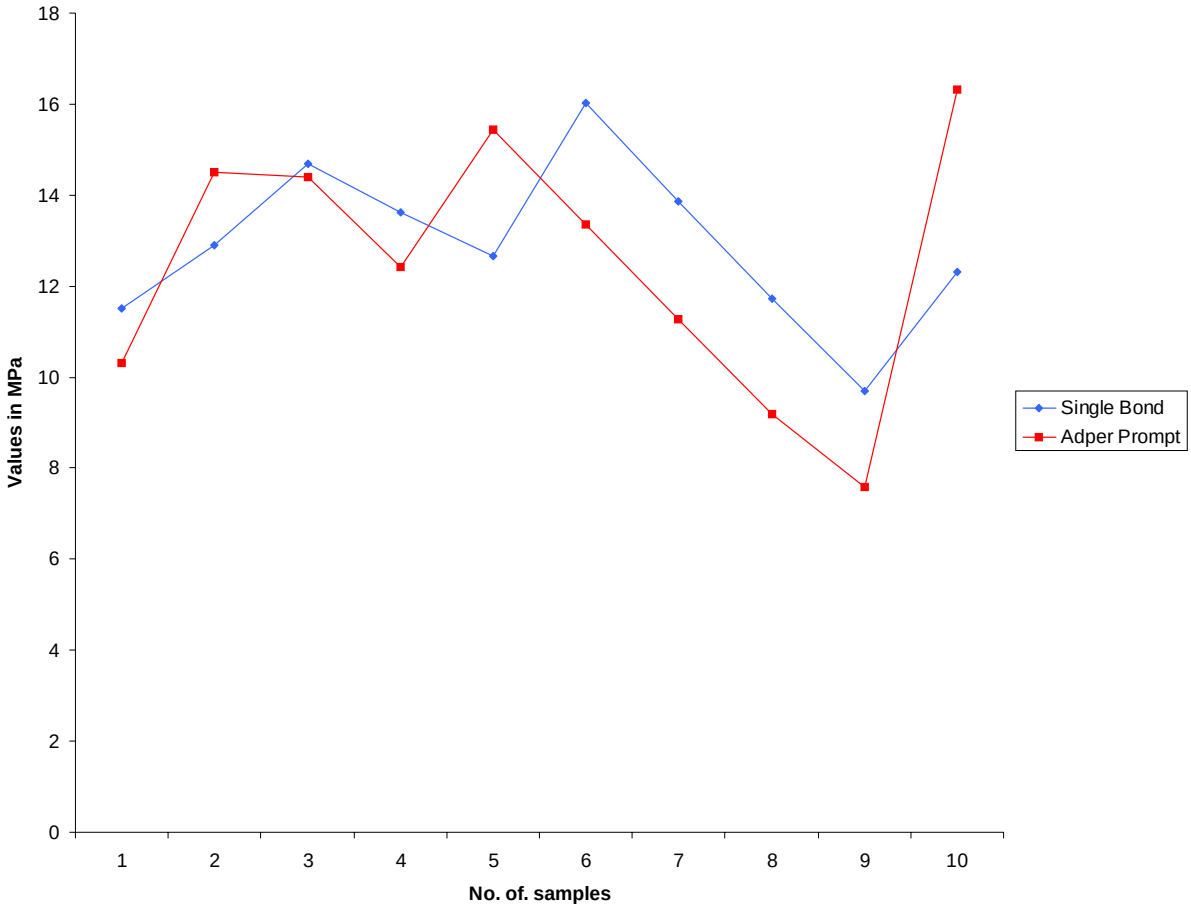


Fig-16 Comparison of Tensile Bond Strength

Fracture mode under SEM:

Three specimens were selected randomly from each group and evaluated under SEM. Debonded surfaces of both dentin and resin cone

of each specimen were observed under SEM and marked as Adhesive / Mixed / Cohesive type of failure as shown in table 4 and in figures 17, 18 & 19.

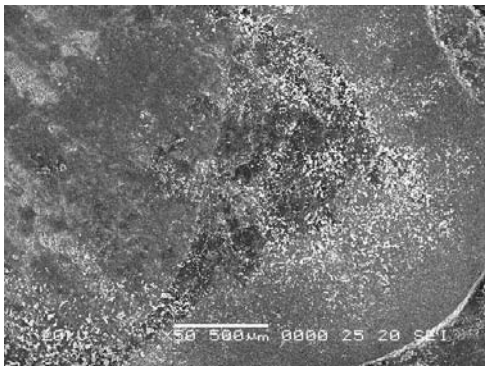
Two specimens from Single Bond group showed resin cohesive failure and two specimens from Adper Prompt group showed mixed type of failure. But neither specimen showed dentin cohesive failure.

Two examiners crosschecked this observation and confirmed the findings. This fracture mode observation was not statistically analyzed and correlated with the tensile bond strength values.

Table-4

FRACTURE MODE UNDER SEM

S.No	Single Bond Group	Adper Prompt Group
1	Adhesive	Mixed
2	Resin cohesive	Resin cohesive
3	Resin cohesive	Mixed



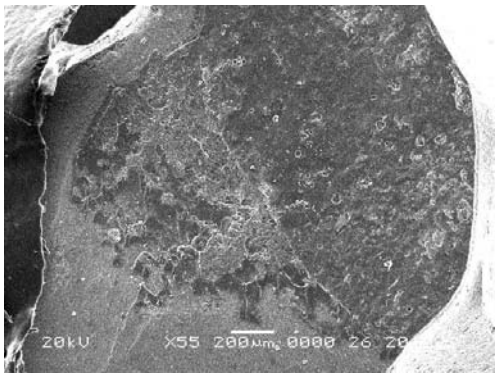


Fig. 17- Adhesive fracture – Group I

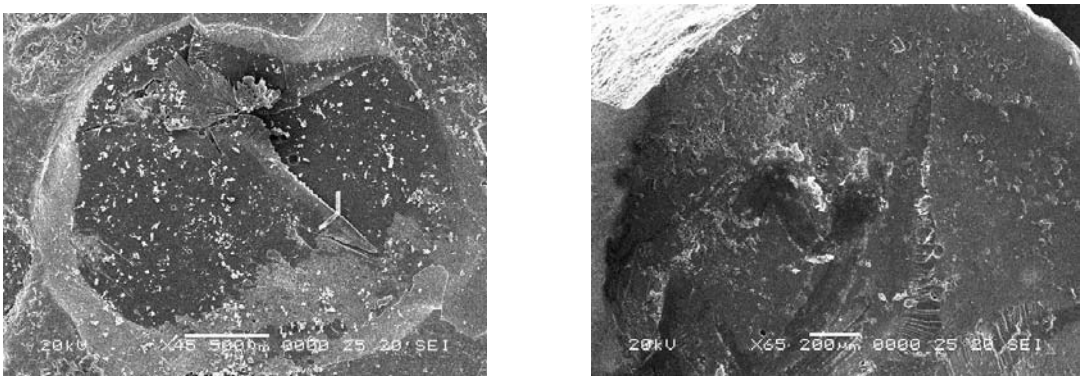


Fig. 18- Mixed type of fracture – Group II

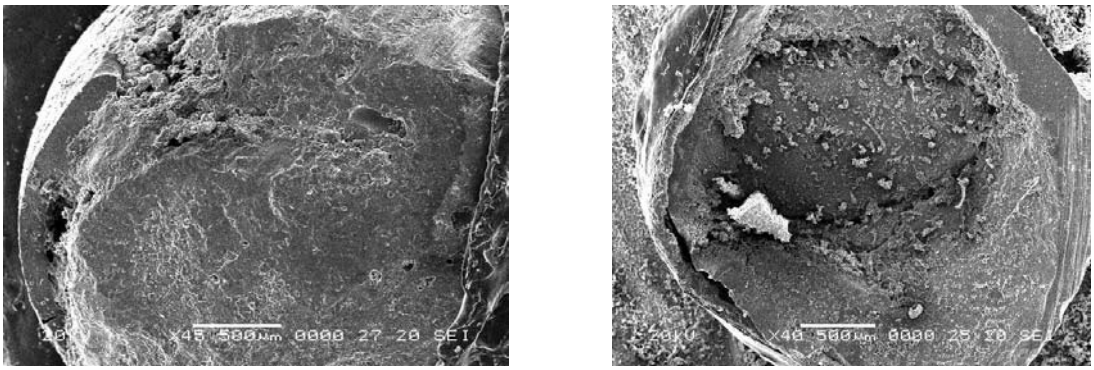


Fig. 19- Cohesive fracture in resin – Group I

Microleakage:

The bucco-lingually sectioned specimens of both groups were examined under stereomicroscope to determine the depth of dye penetration in occlusal, cervical, and axial walls of class V cavities.

The scores for microleakage of ten specimens from each group are presented in table 5.

The number and percentage of specimens from each groups with corresponding microleakage scores are presented in table 6 and in figure 23.

Specimens showing microleakage scores 1, 2 & 3 are presented in figures 20, 21 & 22. No microleakage was observed in 30% of Single Bond group and 20% of Adper Prompt group. Score 3 was not observed in Single Bond group but observed in 10% of Adper Prompt group.

The Chi-square test to find a statistical difference in microleakage of two groups is given in table 7. The obtained P value was higher than 0.05 ($P > 0.05$). It indicates that there is no statistically significant difference.

Table-5

Microleakage

Single Bond	Adper Prompt
0	1
1	0
0	1
0	1
1	1
2	1
1	1
2	0
1	2
1	3

Table 6

Crosstabulation for Microleakage

Microleakage	Groups		Total
	Single bond	Adper prompt	
0	3 (30%)	2 (20%)	5 (25%)
1	5 (50%)	6 (60%)	11(55%)
2	2 (20%)	1 (10%)	3 (15%)
3		1 (10%)	1 (10%)
Total	10(100%)	10(100%)	20(100%)

Table 7

Chi-Square Tests

	Value	Df	Asymp Sig. (2 sided)
Pearson Chi-square	1.200	3	.653
Likelihood Ratio	1.588	3	.662
Linear by Linear Association	.781	1	.377
N of valid cases	20		

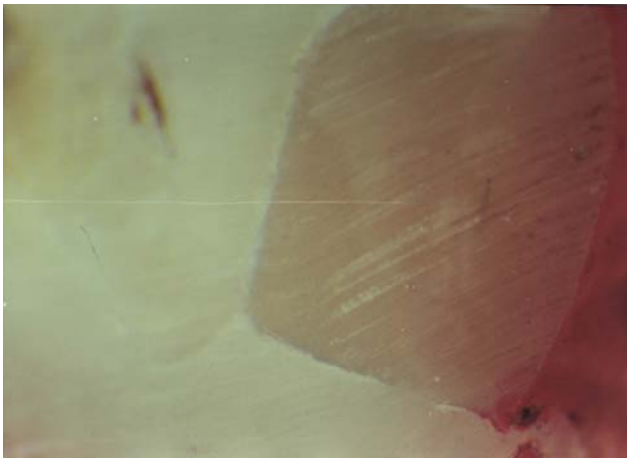


Fig. 20.Microleakage score 1 – Group I

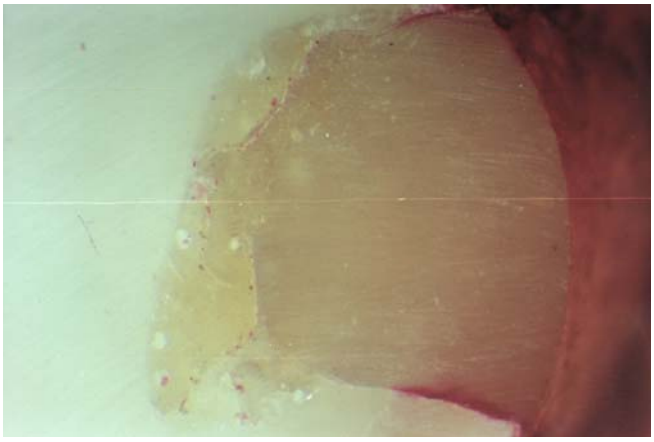


Fig. 21. Microleakage score 2 – Group II

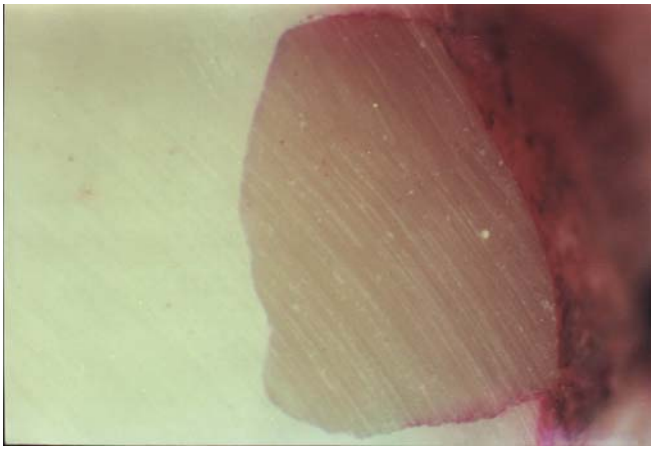


Fig. 22 Microleakage score 3 – Group II

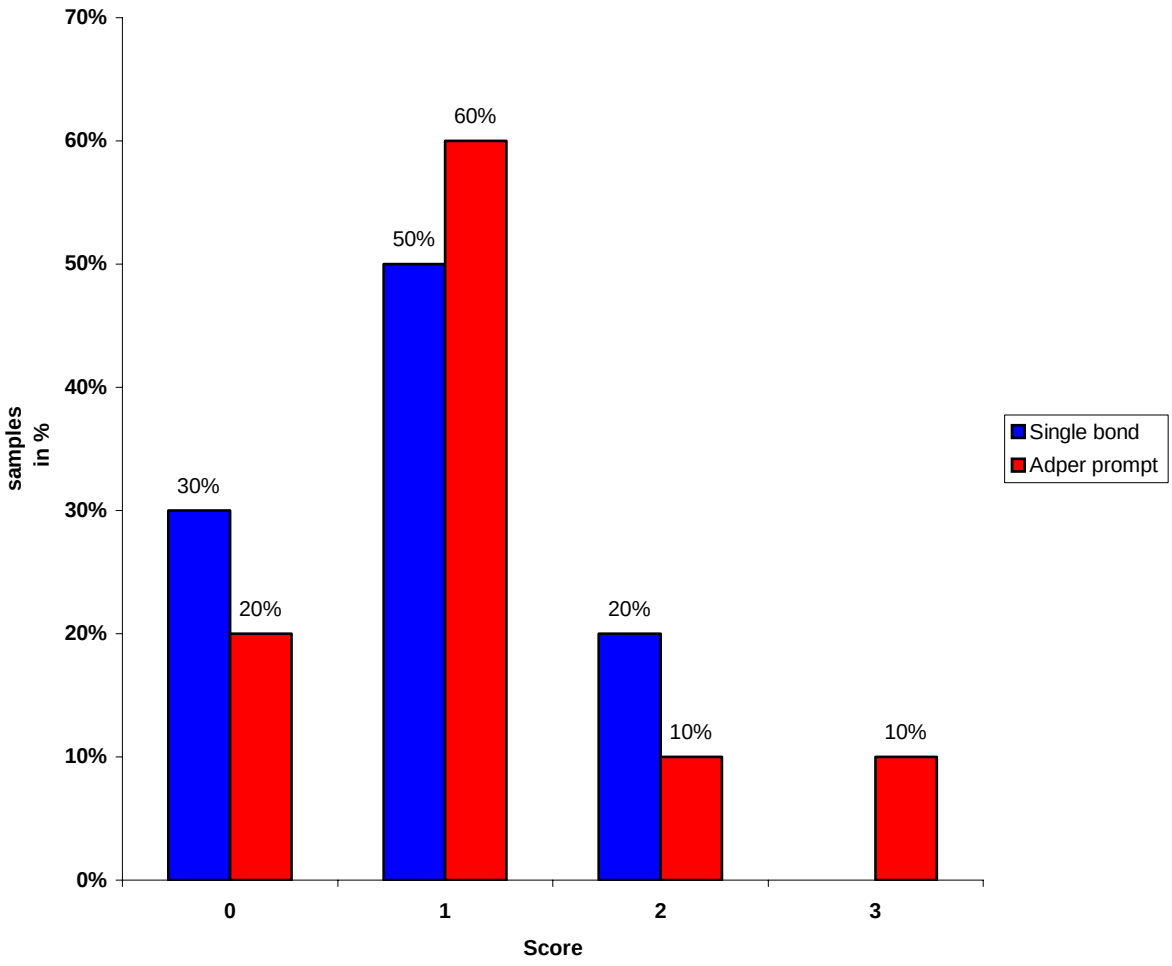


Fig-23 Comparison of Microleakage Scores

Discussion

Bonding to dentin using resin-based materials has become more popular in recent years due to improvements in reliability, bond strength and simplification of placement techniques.

The `traditional' resin-based dentin adhesives use a separate etching or conditioning agent, a primer and a bonding resin, which implies that numerous steps must be completed before the resin composite filling material can be placed. With each steps, the potential exists for saliva or blood contamination, the effects of humidity, or incorrect application time, all of which can have a detrimental effect on the bond strength, sealing ability and life span of a restoration.

As these bonding systems are perceived as being too complicated and time consuming, especially with children, many manufacturers have attempted to simplify the systems by combining certain steps; these products have been designated as the fifth - generation dentin bonding agents.

The fifth generation dentin bonding systems can be subdivided into one-bottle adhesives and self-etching primers. One-bottle systems (total etch) combine the primer and adhesives in one solution to be applied after enamel and dentin are etched with an acid etchant. In this system, the dentin surface should remain in a moist state to prevent collapse of the unsupported collagen and promote primer resin infiltration.

The fifth generation self-etching primer system combines the etching and priming steps, resulting in simultaneous etching and infiltration of

resin into enamel and dentin. It enables resin monomers to penetrate the underlying dentinal substrate through the smear layer without separate etching, rinsing and drying procedures.

More recently, following the trend of simplification, self-etching adhesive systems that combine etching, priming, and adhesive in one solution have been developed. These have been categorized as the sixth - generation dentin bonding systems. In these systems, methacrylated phosphoric esters function as an etching agent in the primer, so that separate acid etching of enamel and dentin is not required. In addition, it enables the resin monomer penetration and co-polymerization into the enamel and dentin through the smear layer[21].

Apart from simplification of bonding techniques, these adhesive systems (fifth & sixth generation) have been confirmed to have similar or higher bond strength, sealing ability and chemical reliability to that of fourth generation in permanent teeth. While bonding to permanent teeth has been studied extensively, few studies have addressed resin bonding to primary teeth[14,26,40].

Studies comparing efficacy of adhesive systems in primary and permanent teeth, showed similar or less efficacy of adhesives in primary teeth due to some chemical, physiological and micromorphological differences[13,26].

This invitro study was conducted to comparatively evaluate the tensile bond strength, fracture mode under SEM and microleakage of fifth generation total etching system (Single Bond) and sixth generation self-etching adhesive system (Adper Prompt) in primary dentin.

In this study, freshly extracted caries free human primary molars were used for tensile bond strength. Water was used as a storage media.

Buccal surface of molars were preferred in this study as flat dentin surface could be prepared which would give wider area of dentin to be treated and bonded to resin. In addition, the oblique pattern of tubule orientation in primary molars would not be a variable in bond strength of adhesives (Zafer C.Cehrelli et al[41]).

Flat dentin surfaces were created using water-cooled disks under careful visual examination. Further it was grinded and polished with 600 grit - silicon carbide paper in a mandril connected with an airmotor handpiece (in wet condition). This preparation was restricted to the superficial dentin just below the dentino-enamel junction. Then two examiners crosschecked the specimens to confirm whether the preparation was on superficial layer of dentin.

Then specimens were embedded in self-cure acrylic block, exposing the ground surface outside. Specimens were divided into 2 groups of 10 teeth each.

Group 1 - 37% Phosphoric acid and Single Bond 3M-ESPE (5th generation total each group) + Composite Z-100 (3M)

Group 2 - Adper Prompt 3M-ESPE (6th Generation - self-etching adhesive group) + Composite Z-100 (3M)

After applying bonding agents, and curing, a metal mould with inverted hollow (2mm diameter at lower end, 4 mm diameter at the top and 5 mm in height) was used to develop a resin cone. This mould was used to restrict the bonding surface area only to 2 mm diameter on the dentin. This results in fewer defects occurring in the smaller area of bonding and higher bond strength. During placement of composite inside the mould, incremental technique was used, to decrease the polymerization shrinkage. Twisted wires were placed after placing 2 mm thickness of composite resin and cured. The remaining 3 mm was restored with composite in two increments and cured separately.

After complete curing of composite, metal mould was removed and reused for other specimens in the same way. When removing the mould, a spontaneous bond failure occurred in some specimens of both group as noted by a similar study conducted by Francesca G.Agostini[14]. It might be due to high water content of these adhesives. These specimens were discarded and not included in the study.

A tensile force was applied to test the bond strength. For evaluation of an adhesive material at least six types of adhesion tests can be performed - lap shear, cleavage, tensile, impact, bending and peel. Normally in invivo conditions, dental adhesives used are more likely to be subjected to shear forces, but the ability of the adhesives resin to retain on the tooth surface ultimately depends on the resistance it offers to tensile forces, so tensile bond strength was evaluated in this study[1]. The bond strengths were tested using the Instron Universal Testing Machine, as it is the standard machine used for various tensile and shear bond tests.

The results were statically analyzed, the mean, standard deviation and 95% confidence interval were estimated from the samples of both groups (Table 2&3). The mean value of the samples for group 1 was 12.91 ± 1.77 and for group 2 was 12.46 ± 2.83. Results from t-test showed that the P-value >0.01 and no statistically significant difference in between these two groups.

Results of this invitro study shows that both adhesive systems performed equally in primary dentin without any statistically significant difference in terms of tensile bond strength measurement.

Bond strength of self etch adhesive system have been found higher in enamel, in studies conducted by M.Hannig et al[23], and Fancesca G.Agostini et al[14]. But, results of studies revealing its efficacy in dentin was controversial[26,14].

For effective bond strength in dentin, the adhesive system should produce an intermingled layer of resin monomers and organic portion (collagen fibres) of dentin, known as hybridization zone. The quality of hybrid layer may be varied depending upon the pH of etchant, ability of the resin monomer to flow into the demineralized dentin and chemo-physiological and morphological characteristics of dentin (especially in primary dentin).

Concerning the C-factor, this study was conducted on flat dentin surface. The results were lower in both the group on primary dentin even the C-factor was 1. It may be due to the fact that the area of solid dentin that is available for dentin bonding is significantly reduced in primary teeth (David A. Sumikawa et al[7]). The density and diameter of the dentinal tubules in primary molars were lower than the values reported for permanent teeth and may account for the lower permeability of the primary molars (V.Koutsi et al[36] 1994).

Another factor for lower bond strength obtained in both groups may be the fact that both systems are HEMA containing, water based products from 3M (ESPE) Dental Manufacturer. Because of higher water content, these systems are very sensitive to water content, of demineralyzed dentin especially during polymerization and formation of hybrid layer. The total etch system (Single Bond) with water was considered more sensitive to

overwet and overdrying procedure even though it contains ethanol (Y Nakoki et al[37] 2002).

The finding that the change in cure was most significant within the 0 to 0.20 ML water per ML of bonding resin range could be of great clinical significance. Consequently, relatively small water contamination could have dramatic effects on the bond strength and render this type of material very technique sensitive (Jacobson et al[33] 1995).

Incomplete removal of water from the collagen network results in the competition between the monomer and the remaining water inside the demineralized dentin and might inhibit polymerization of the bonding agent. Phase separation of the hydrophobic and hydrophilic monomer components causing blister - like spaces and globule formation of the bonding agent within the hybrid layer has been observed in overwet conditions. In addition, excess water may also dilute the primer and render it less effective.

The self etch system (Promp-L-Pop) with more water content may be more sensitive when it is applied 2 or 3 coats on the dentin. It results in appearance of watery film over the bonded surface of dentin. A possible reason for this phenomenon could be the high water content of these bonding systems released during polimerization. It was suggested by Francesca G. Agostini et al[14] (2001).

In the present study, the self etching system produced equal strength to that of total etching system. It may be due to the fact that the

low pH of the Adper Prompt adhesive dissolved the smear layer completely and formed the hybrid layer without any smear plugs that is very similar to that of total etch system. Franklin R. Tay and Pashley D.H.[15] (2001) demonstrated more aggressive nature of self etch system (Prompt-L-Pop), that completely dissolved the smear layer and smear plugs and formed the hybrid layer with a thickness approaching those of phosphoric acid conditioned dentin, in permanent molars.

In our study, for SEM examination of failure sites, samples were selected from each group, using systematic random sampling method that is every third specimens (3, 6 & 9) from each group of 10 specimens. It might represent the majority of fracture mode of each group.

In Single Bond group, 2 out of 3 specimens showed cohesive fracture in the resin. It might be due to higher bond strength of adhesive on the dentin. In Adper Prompt group, 2 out of 3 specimens showed mixed type of fracture and 1 specimen showed cohesive resin fracture. It may also be considered due to higher bond strength of adhesive. But these findings, could not be correlated statistically with bond strength measurements.

Microleakage occurring along the restoration - tooth interface is possibly the greatest deterrent to the development of an `ideal' restorative material. Changes in temperature, polymerization shrinkage and mechanical stress may result in openings developing at the tooth material junction. This leakage will permit ingress of deleterious agents. Such as acids, food debris and micro organisms between the walls of the prepared cavity and the restoration.

Microleakage may be the precursor of secondary caries, marginal deterioration, post-operative sensitivity and pulp pathology. Microleakage poses a particular problem in the pediatric patient in whom the floor of the cavity preparation in primary dentition may be close to the pulp. Hence, sealing of the cavity walls besides its retention remains an important factor while determining the efficacy of a material. Further the microleakage study, together with the bond strength testing provide good screening methods to determine if adhesive systems will be clinically acceptable.

Many techniques have been devised to test the cavity sealing properties of restorations both invivo and in vitro. In vitro studies include the use of dyes, chemical tracers, radioactive isotopes, airpressure, bacteria, neutron, activation analysis, SEM, artificial caries techniques and electrical conductivity. The use of organic dyes as tracers is the most common method detecting leakage in vitro and it is detectable even in dilute concentrations, in expensive, and non-toxic. In this study, basic fuchsin dye was used. Microleakage was studied using a stereomicroscope.

In all types of composite restorations, the sealing ability of bonding agents is the main variable determining the marginal leakage. Recent studies on bonding agents (5th & 6th) confirmed that none of the adhesives capable of completely stopping microleakage in composite restorations and results were controversial and variable.

In this study, class V cavities (3mm width, 2 mm height & 2 mm depth) were prepared on buccal/lingual surfaces of the primary molars using a 330 bur in an airotor handpiece. Two examiners crosschecked all

the specimens to confirm that the above-mentioned mesearments of class V cavity preparation were adhered to.

After adhesive treatment in both groups (10 specimens of each), composite resin was placed inside the cavity using bulk filling technique since the cavity depth was only 2 mm.

Specimens were thermocycled (5^0 to 55^0 C) for 200 cycles. After thermocycling, impermeation of teeth apex with warm wax and nail varnish application around 1 mm of margins of restoration done. Then it was immersed in 2% basic fuchsin dye for 24 hrs. Then longitudinally sectioned with diamond disks and examined under stereomicroscope. Microleakage was scored by using the scoring criteria used by A El. Housseiny et al[3] (2000).

In our study, we found score 3 microleakage in one specimen, score 2 microleakage in one specimen and score 1 microleakage in 6 specimens and score - 0 in 2 specimens of sixth generation group self etch group, compared to score -0 in 3 specimens, score -1- in 5 specimens, score - 2 in 2 specimens of fifth generation total etch group.

Although score -3 was noted in one specimen from self etch group, the result obtained from Chi-square test revealed no statistical difference between sixth generation self etching adhesive system and fifth generation total etch adhesive system in their microleakage score/sealing ability. This result correlates with the findings of R.M. Gagliardi et al[28], D.Gillet et al[5],

Danielson Guedes Pontes et al[6]. This can be explained by the facts that the monomers that cause etching in sixth generation system are also responsible for the bonding and that the depth of demineralization zone corresponds to the depth of penetration of monomers. As the etching process progresses, the pH of the phosphoric esters rises, as dentin buffers the acidic monomers, and this process inhibits further demineralization (Danielson Guedes Pontes et al[6]).

But Paloma Dias da Silva Telles et al[26] found more interfacial opening of restoration in Prompt-L-pop group than in Single Bond group and speculated that the low pH of self etch adhesive (Prompt-L-pop) which is required for the etching of tooth structure may have impaired the polymerisation of the resin monomer and therefore not allowed for the development of a strong and stable hybrid layer to prevent the opening of interfacial gaps.

In our study both the systems, were unable to prevent microleakage in class V cavities. It was demonstrated in studies conducted by Heping Li et al[18] and A. Ruya Yacizi et al[2] and Danielson Guedes Pontes et al[6]. Heping Li et al found more leakage in Single Bond and Prompt-L-Pop groups than in Clearfil SE Bond and Unifil bond. Ruya Yacizi et al found more leakage in Gluma one bond (fifth generation total etch adhesive system) and Prompt-L-Pop compared to optibond FL and clearfil SL Bond from fifth generation self etching primer system (With & Without acid etching). There is a possibility that the lack of a separate primer may

reduce the infiltration depth or the wettability of dentin adhesives, thereby reducing adhesion and sealing capacity of Prompt-L-Pop.

Danielson Guedes Pontes et al observed less leakage in Prompt-L-Pop group when it is used on enamel, but showed similar leakage to that of Single Bond group in dentin. The total etch system also was not able to prevent microleakage in our study. It may be due to the fact that the single bottle adhesives containing ethanol/acetone are more sensitive to the moisture content of demineralised dentin. It could have profound effect on sealing ability of this system (Y Nakoki et al[37] 2002).

Several authors have reported superior results when Prompt L Pop is used with polyacid modified resin composites ("Compomers")[26]. Since the compomers are hydrophilic restorative materials, they are more compatible with Prompt-L-Pop, which is a water-based material. On the other hand, resin composites are hydrophobic restoratives, and this may explain why severe microleakage was observed in this group. However, there were no statistically significant differences between the two groups tested.

Due to the reduced mineral content of primary dentin compared to permanent dentin, a different effect of acid conditioning on primary dentin has been suggested as a possible explanation. Using 10% maleic and 10% phosphoric acid and two different bonding system, Nör et al., reported that the hybrid layer produced in primary teeth was 25-30% thicker than in permanent teeth and concluded that primary dentin was more reactive to acidic conditioners. Olmez later confirmed these observations using 37% phosphoric acid[14].

Paloma Dias da Silva Telles et al[26] demonstrated minimal or no thickness of the hybrid layer following the use of self etching adhesive (Prompt-L-Pop) in dentin when compared to that of total etch system (Single Bond) with compomer and composite resin material. In this study, the difference between primary Vs permanent and compomer Vs composite in terms of thickness of hybridization zone was not demonstrated statistically.

Conclusion

An invitro study was conducted to comparatively evaluate the tensile bond strength to primary dentin, fracture mode under SEM and microleakage in class V cavity preparations of fifth generation adhesive-Single Bond with that of sixth generation adhesive-Adper Prompt in primary molars.

Considering the aims with which the present study was undertaken, the following conclusions may be made:

1. There was no significant difference between two adhesive systems when considering both tensile bond strength and microleakage in primary molars.

2. Both total etching -single bottle system and self-etching adhesive system proved to be equally effective in providing bonding of composite resin restorations in primary dentin.

3. Both the systems showed lower tensile bond strength and also failed to prevent microleakage in primary molars. It may be due to the chemo-morphological difference in primary dentin or higher sensitivity of water containing adhesive systems in bonding techniques. But further studies are needed to confirm these suggestions.

4. Considering the application steps, the self etch adhesive is applied by a single step, without the need for separate etching / rinsing / drying procedures, there by minimizing the risk of contamination & failure of bonding in clinical situation as well as the time required for bonding, especially in children. So, the sixth generation self-etching adhesive systems can be considered better than the total etching systems in primary dentition.

Since this is an invitro study, further invivo investigations are needed to come to a definite conclusion in relation to our findings.

Bibliography

1. **Anusavice KJ.**

   Philips' Science of dental materials: Mechanical properties of dental materials. 11th ed. New Delhi, Saunders publication, 2003:73-101.

2. **A. Ruya Yazici, Meserret Baseren, Berrin Dayangac.**

   The effect of current generation bonding systems on micro leakage of resin composite restorations.

   Quintessence Int. 2002; 33: 763-769.

3. **A EL Housseiny and N Farsi.**

   Sealing ability of a single bond adhesive in primary teeth. An in vivo study.

   Int J Pediatr Dent. 2002; 12: 265-270.

4. **C Lucena-Martin, MP Ganzalez – Rodriguez, CM Ferrer –Luque, V. Robles-Gijon, JM Navajas.**

   Influence of time and thermocycling on marginal sealing of several dentin adhesive systems.

   Operative Dentistry. 2001; 26: 550-555.

5. **D. Gillet, J. Nancy, V. Dupuis, G. Dorignac.**

   Microleakage and penetration depth of three types of materials in fissure sealants: Self -etching primer Vs etching; an invitro study.

   J Clin pediatric Dent. 2002; 26(2): 175-178.

6. **Danielson Guedes pontes, Ariana Tavares de Melo, Antonio Fernando Monnerat.**

   Micro leakage of new all-in-one adhesive systems on dentinal and enamel margins.

   Quintessence Int. 2002; 33: 136-139.

7. **David A sumikawa, Grayson W. Marshall, Lauren Gee, Sally J. Marshall.**

   Microstructure of primary tooth dentin.

   Pediatr Dent. 1999; 21: 439-444.

8. **Donald C. Schmitt, Jacob lee.**

   Microleakage of adhesive resin systems in the primary and permanent dentitions.

   Pediatric Dent, 2002; 24: 587-593.

9. **ED Bonilla, RG Stevenson, M Yashar, AA Caputo**.

   Effect of application technique and dentin bonding agent interaction on shear bond strength.

   Operative Dentistry. 2003; 28: 5, 568-573.

10. **Edward J Swift, Jorge Pedrigao, Harald O. Heymann.**

    Enamel bond strengths of “one-bottle” adhesives.

    Pediatr Dent. 1998; 20: 259-62.

11. **Edward J. Swift, Pedrigao.**

Clinical evaluation of two one bottle dentin adhesives at three years.

JADA. 2001; 132: 1117-1123.

12. **Edward J. Swift.**

Dentin/enamel adhesives: review of the literature.

Pediatr Dent. 2002; 24(5): 456-461.

13. **Edward J. Swift.**

Bonding Systems for restorative materials – a Comprehensive review.

Pediatr Dent. 1998; 20(2): 80-84.

14. **Francesca G. Agostini, Christoph Kaaden, John M. Powers.**

Bond strength of self–etching primers to enamel and dentin of primary teeth.

Pediatr Dent. 2001;23: 481-486.

15. **Franklin R. Tay, David H. Pashley.**

Aggressiveness of contemporary self-etching systems I: Depth of penetration beyond dentin smear layers.

Dental Materials. 2001; 17: 296-308.

16. **Gerald Kugel and Marco Ferrarri.**

The science of bonding: From first to sixth generation.

JADA, 2000; 131: 20-25.

17. **Guilherme Carpena Lopes, Luiz Narciso Baratieri, Mauro A. Caldeira de Andrada, Luiz Clovis C. Vieira.**

Dental adhesion: Present state of the art and future perspectives.

Quintessence Int. 2002; 33: 213-224.

18. **Heping Li, Michael; F. Burrow, martin J. Tyas.**

The effect of load cycling on the nanoleakage of dentin bonding systems.

Dental materials. 2002; 18: 111-119.

19. **J. Perdigao, KN may, AD Wilder, M. Lopes.**

The effect of depth of dentin demineralization on bond strengths & morphology of the hybrid layer.

Operative Dentistry. 2000; 25: 186-194.

20. **JR Gallo, JO Burgess, X. Xu.**

Effect of delayed application on shear bond strength of four fifth generation bonding systems.

Operative Dentistry. 2001; 26: 48-51.

21. **K.K. Saraf, Ashok Kumar, S.K. Mishra.**

Bonding Systems for the new millennium.

JADA. 2000; 73: 163-168.

22. **L. Zheng, PNR Pereira, M. Nakajima, H Sano, J Tagami.**

Relationship between adhesive thickness and microtensile bond strength.

Operative Dentistry. 2001; 26: 97-104.

23. **M. Hannig, K.J. Reinhardt, B Bott.**

Self etching primer Vs Phosphoric acid. An Alternative concept for composite to enamel bonding.

Operative Dentistry. 1999; 24: 172-180.

24. **M. Yoshiyama, A. Urayana, T. Kimochi, T, Matsuo, Pashley.**

Comparison of conventional Vs self etching adhesive bonds to caries – affected dentin.

Operative Dentistry. 2000; 25: 163-169.

25. **P.N.R. Pereira, M. Okuda, H. Sano, T Yoshikawa, M.F. Burrow, J. Tagami.**

Effect of intrinsic wetness and regional difference on dentin bond strength.

Dental materials. 1999; 55: 46-43.

26. **Paloma Dias da Silva Telles, Maria Aparecida A. Moreira Machado, Jacques Eduardo Nor.**

SEM study of a self etching primer adhesive system used for dentin bonding in primary and permanent teeth.

Pediatr Dent. 1998;l20(4): 315-320.

27. **R Sakoolnamarka, MF Burrow, and MJ Tyas**.

Micromorphological study of resin dentin interface of noncarious cervical lesions.

Operative Dentistry, 2002; 27: 493-499.

28. **R.M. Gagliardi, R.P. Avelar.**

Evaluation of microleakage using different bonding agents.

Operative Dentistry. 2002; 27: 582-586.

29. **S Guzman-Armstrong, SR Armstrong, F Qian.**

Relationship between nanoleakage and microtensile bond strength at the resin dentin interface.

Operative Dentistry. 2003; 28: 60-66.

30. **Susanne Szep, Dr Med Dent, Nicole Langner, Silja Bayer, Diana Bornichen, Christoph Schulz, Thomas Gerhardt et al.**

Comparison of microleakage on one composite etched with phosphoric acid or a combination of phosphoric and hydrofluoric acids and bonded with several different systems.

J Prosthet Dent. 2003; 89: 161-90.

31. **T. Yoshikawa, H. Samo, M.F. Burrow, J. Tagami, D.H. Pashley.**

Effects of dentin depth and cavity configuration on bond strength.

J Dent Res.1999; 78(4): 898-905.

32. **Takeshi KIMOCHI, Masahiro YOSHIYAMA, Akihisa URAYAMA & Takeshi MATSUO.**

Adhesion of a new commercial self-etching/self priming bonding resin to human caries- infected dentin.

Dental materials.1999; 18(4): 437-443.

33. Thomas Jacobson, Karl-Johan soderholm.

Some effects of water on dentin bonding.

Dental materials. 1995; 11: 132-136.

34. Theodore P. Croll.

Self etching adhesive system for resin bonding.

J Dent Child. 2000; 67:176-181.

35. Tsuneo IMAI, Kazuo ITOH, Chihiro TANI.

Effectiveness of simplified dentin bonding systems.

Dental materials. 1998; 17(1):1-10.

36. V. Koutsi, Noonan, J.A. Horner, M.D. Simpson, W.G. Mathews, D.H. Pashley.

The effect of dentin depth on the permeability and ultrastructure of primary molars.

Pediatr Dent. 1994; 16: 29-35.

37. Y Nakaoki, T. Nikaido, M.F. Burrow and J. Tagami.

Effect of residual water on dentin bond strength and hybridization of a one-bottle adhesive system.

Operative Dentistry. 2002; 27: 563-568.

38. Y Shimada, P senawongse, C Harrnirattisai, MF Burrow, Y Nakacki, J Tagami.

Bond strength of two adhesive systems to primary and permanent enamel.

Operative Dentistry. 2002; 27: 403-409.

39. **Y Shimada, N Iwamoto, M Kawashima, MF Burrow, J Tagami.**

Shear bond strength of current adhesive systems to enamel, dentin and dentin –enamel junction region.

Operative Dentistry. 2003; 28(5): 583-590.

40. **Yumiko Hosoya, Yumiko Kawashita, Makoto Yoshida, Chikako Suefuji, Grayson W. Marshall.**

Fluoridated light activated bonding resin adhesion to enamel and dentin. Primary Vs Permanent.

Pediatr Dent. 2000; 22(2): 101-106.

41. **Zafer C. Cehrelli, Taner Akca.**

Effect of dentinal tubule orientation on the microtensile bond strength to primary dentin.

J. Dent child. 2003; 70(2):139-144.

42. **Ziad D.Baghdadi.**

Bond strength of Dyract AP compomer material to dentin of permanent and primary molars; Phosphoric Acid versus Non-rinse Conditioner.

J Dent Child. 2003; 70(2):145-152.